RICE WHOLE CROP SILAGE FEEDING AND GRAZING: GROWTH PERFORMANCE, CARCASS CHARACTERISTICS AND MEAT QUALITY IN JAPANESE BLACK STEERS.

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Abstract – This study aimed to investigate the differences in growth performance, carcass characteristics and meat quality between Japanese Black steers fed rice whole crop silage (WCS) after grazing (GS) and those fed concentrate (CT). The body weight (BW) of the GS group at 23 months of age after grazing was significantly lower than that of the CT group. Thereafter, the BW of the GS group was restored by feeding indoors a large amount of rice WCS. There was no significant difference in the final BW between the two groups. This result suggests that compensatory growth would have started by feeding a large amount of rice WCS after grazing. The rib thickness was significantly less in the GS than in the CT group. The beef marbling standard and muscle fat content were significantly lower in the GS than in the CT group. In contrast, the crude protein content in muscle of the GS group was significantly higher than that of the CT group. These results suggest that feeding steers a large amount of rice WCS after grazing is effective for beef production.

I. INTRODUCTION

In Japan, beef cattle are reared under restricted movement and generally finished indoors on a concentrate-based diet throughout the fattening period until slaughter. Recently, beef cattle production has made use of grazing, with effective utilization of roughage in the field. Our previous study showed that feeding a large amount of grass hay to steers indoors led to an increase in protein content and a decrease in fat accumulation in the muscle compared with feeding a concentrate-based diet but grass hay-fed steers had a lower final body weight (BW) because of the lower total digestible nutrient (TDN) intake (1). A previous report found a decrease in crude fat content in muscle and in beef marbling standard (BMS) number of grazed cows in comparison with those of concentrate-fed steers (2). The crude fat content in muscle was much lower in grass hay-fed steers (3) and pasture-fed steers (4) than concentrate-fed steers.

Recently, 'Tachisuzuka', a new rice cultivar for whole-crop silage (WCS), has been developed at the NARO Western Region Agricultural Research Center (NARO/WARC), Japan and exhibits a high straw yield, high sugar content, high digestibility of fiber and low grain yield (5).

The purpose of the present study is to investigate the influence of rice WCS feeding after grazing on the growth performance, carcass characteristics and meat quality of Japanese Black steers.

II. MATERIALS AND METHODS

Animal Management and Diets

The management of the steers and all procedures were performed according to the Animal Experimental Guidelines of NARO/WARC. Ten 10-month-old Japanese Black steers, bred at NARO/WARC, were randomly divided into two groups: a combination of grazing and whole-crop rice silage-fed (GS) group and concentrate-fed (CT) group. The steers were housed individually in a tie stall barn and fed concentrate diet *ad libitum* and 1.5 kg/day grass hay from 10 until 16 months of age. After this control period, the four steers in the GS group were rotationally grazed on Italian ryegrass pasture until 23 months of age and then reared individually in a tie stall barn and fed a rice WCS *ad libitum* and concentrate diet from 23 to 28 months of age. The other six steers in the CT group continued with the concentrate and grass hay diet in the tie stall

barn until 28 months of age. The steers were weighted every 1–2 weeks to record body weight. Food intake was measured daily except during the grazing period. The steers were all slaughtered at 28 months of age.

Carcass Evaluation and Sample Preparation
After slaughter, the carcasses were chilled at 0°C for 24 h, then evaluated by calculating their dressing percentage and by measuring the rib eye area, rib thickness, subcutaneous fat thickness, BMS, beef fat color standard (BFS) and beef color standard (BCS) of the section between the sixth and seventh ribs according to the Japanese New Beef Carcass Grading Standards (6). Skeletal muscle tissue from the *longissimus lumborum* (LL) and *semitendinosus* (ST) muscles were obtained for nutrient content and other analyses. The muscle tissues were minced to determine the crude protein content and crude fat content. The minced meat samples were vacuum-packed in an aluminum bag and then stored at -80°C until analysis.

Nutrient Content in Muscle
The crude protein in each muscle was calculated by quantitative analysis of nitrogen using the Kjeldahl method with copper sulfate and potassium sulfate as catalysts (7). The crude fat in each muscle was extracted with diethyl ether for 16 h using a Soxhlet extractor (7).

Statistical Analysis
All measurements are presented as means. The differences between the mean values from the GS and CT groups were analyzed using one-way ANOVA and a post-hoc Fisher test. A P value of < 0.05 was considered to be statistically significant.

III. RESULTS AND DISCUSSION

The growth performance and TDN intake of the GS and CT groups are shown in Table 1. There were no differences in BW and the TDN intake between the GS and CT groups during the control period before grazing. The BW of the GS group at 23 months of age after grazing was significantly lower than that of the CT group. In general, energy expenditure increases in grazing cattle compared with indoor feeding cattle. The reduction in BW at 23 months of age suggests that there may have been an increase in energy expenditure caused by grazing, even though energy or nutrient intake was not measured during grazing period. However, this decrease in the BW of the GS group was only temporary; thereafter, because the BW of the GS group was restored by indoor feeding a large amount of rice WCS, there was no significant difference in final BW between the two groups. Previous work has reported that compensatory growth can take place when cattle are offered sufficient barley-alfalfa pellets after grazing at low grazing pressure compared with high grazing pressure (8). In the present study, the TDN intake of the GS group during the WCS feeding period after grazing was significantly higher than that of the CT group. These results suggest that compensatory growth would have started by feeding a large amount of rice WCS after grazing.

Table 1 Growth performance and feed intake of steers.

	GS	CT
Body weight (BW), kg		
Initial (10 months)	299	299
Before grazing (16 months)	501	512
After grazing (23 months)	584 *	690
Final (28 months)	722	770
TDN intake, kg/day		
Control period	6.32	6.54
Grazing period	-	6.70
WCS feeding period		
Roughage	1.92 *	0.55
Concentrate	5.41	5.37
Total of both diets	7.33 *	5.93

TDN: total digestible nutrients, WCS: whole crop silage.
Values are expressed as means. *$P < 0.05$

The carcass characteristics of the GS and CT groups are shown in Table 2. Most of the indices of beef productivity, such as dressed carcass weight, dressing percentage and rib eye area, showed no significant differences between the GS and CT groups, but the rib thickness was significantly less in the GS group than in the CT group. A previous report has shown that Japanese Black steers, reared using a combination of restricted feeding of concentrate and grass hay *ad libitum,* had a

decreased rib thickness compared with those fed concentrate *ad libitum* (3). We have reported earlier that a reduction in rib thickness occurred when steers were fed a large amount of grass hay during the indoor fattening period (1). These results agreed with those of the present study which suggest that steers fed a large amount of roughage or restricted feeding of concentrate are subject to a decrease in rib thickness.

Table 2 Carcass characteristics and nutrient content of LL and ST muscles.

	GS	CT
Dressed carcass weight, kg	441	485
Dressing percentage, %	71.9	71.7
Rib eye area, cm^2	45.6	52.7
Rib thickness, cm	6.25 *	7.37
Subcutaneous fat thickness, cm	2.43	3.78
Beef marbling standard (BMS), No.	4.0 *	5.2
Beef color standard (BCS), No.	4.5	4.0
Beef fat color standard (BFS), No.	3.8	2.8
Crude protein, %		
LL muscle	18.6 *	16.2
ST muscle	20.6	20.1
Extract lipid, %		
LL muscle	18.1 *	30.3
ST muscle	5.85 *	11.5

LL: *M. longissimus lumborum*, ST: *M. semitendinosus*, Values are expressed as means. *$P < 0.05$

The BMS, which is one of the indicators of intramuscular fat content, was significantly lower in the GS group than in the CT group (Table 2). Furthermore, the extracted lipid content from the LL and ST muscles was significantly lower in the GS group than in the CT group (Table 2). The BMS number and crude fat content in muscle was lower in grazed cows than in concentrate-fed steers (2). Previous reports have described a decrease in the crude fat content in the muscle of grass hay-fed (3) and pasture-fed (4) steers in comparison with those of concentrate-fed steers. Moreover, the crude protein content in the LL muscle of the GS group was significantly greater than that of the CT group, but there was no significant difference in the ST muscle between the two groups (Table 2). No changes in protein content have been found between muscles from grazed steers (9) or forage-fed steers (10) and concentrate-fed steers. On the other hand, a previous report revealed that the protein content in muscle was lower in grass-fed steers than in grain and grass-fed steers (11). The present study suggests that feeding steers rice WCS *ad libitum* after grazing results in a decrease in muscle fat accumulation and a tendency for muscle protein content to increase compared with concentrate-fed steers.

IV. CONCLUSION

Although BW decreased temporarily after grazing, it had been restored after feeding indoors a large amount of rice WCS. This suggests that compensatory growth would have started by feeding a large amount of rice WCS after grazing. Furthermore, the present study suggests that feeding steers rice WCS *ad libitum* after grazing results in a decrease in muscle fat accumulation and a tendency for muscle protein content to increase compared with concentrate-fed steers.

ACKNOWLEDGEMENTS

The authors appreciate the help of the technical staff at the NARO/WARC. This work was supported in part by a Grant-in-Aid from the Ministry of Agriculture, Forestry and Fisheries of Japan.

REFERENCES

1. Shibata, M., Matsumoto, K., Hikino, Y., Oe, M., Ojima, K., Nakajima, I., Muroya, S., Chikuni, K. & Yamamoto N. (2012). Effect of Grass Hay Feeding on Meat Production, Carcass Characteristics, and Meat Quality in Japanese Black Steers. Bulletin of NARO Western Region Agricultural Research Center, 11, 15-25.
2. Tanimoto, Y., Senda, M., & Koyama, N. (2004). Meat quality of Japanese Black multiparous cows grazed on abandoned fields and the evaluation of their meat using consumer survey questions. Bulletin of National Agricultural Research Center for Western Region, 3, 1–14. (in Japanese)
3. Muramoto, T. Aikawa, K. Shibata, M. & Nakanishi, N. (2002). Effect of restricted feeding of concentrate over the entire fattening period on beef productivity of Japanese Black

Steers. Nihon Chikusan Gakkaiho, 73, 57-62. (in Japanese)
4. Muramoto, T., Higashiyama, M. & Kondo, T. (2005). Effect of pasture finishing on beef quality of Japanese Shorthorn Steers. Asian–Australasian Journal of Animal Science, 18, 420-426.
5. Matsushita K., Iida S., Ideta O., Sunohara Y., Maeda., Tamura Y., Kouno S., & Takakuwa M. (2011). 'Tachisuzuka', a new rice cultivar with high straw yield and high sugar content for whole-crop silage use. Breeding Science, 61, 86-92.
6. JMGA (1988). New Beef Carcass Grading Standards. Japan Meat Grading Association, Tokyo.
7. AOAC. (1990). Official Methods of Analysis (15th Ed.). Association of Official Analytical Chemists, Arlington, VA, USA.
8. Horton, G.M.J., & Holmes, W. (1978). Compensatory growth by beef cattle at grassland or on an alfalfa-based diet. Journal of Animal Science, 46, 297-303.
9. French, P., O'Riordan, E. G., Monahan, F. J., Caffrey, P. J., Vidal, M., Mooney, M. T., Troy, D. J., & Moloney, A. P. (2000). Meat quality of steers finished on autumn grass, grass silage or concentrate-based diets. *Meat Science*, 56, 173-180.
10. Schroeder, J. W., Cramer, D. A., Bowling, R. A., & Cook, C. W. (1980). Palatability, shelf life and chemical differences between forage- and grain-finished beef. Journal of Animal Science, 50, 852-859.
11. Srinivasan S., Xiong Y. L., Blanchard S. P., & Moody, W.G. (1998). Proximate, mineral and fatty acid composition of semimembranosus and cardiac muscles from grass- and grain-fed and zeranol-implanted cattle. *Food Chemistry*, 63, 543-547.